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# Evaluation for an integrated pest management program for northern corn rootworm extended diapause

## **Abstract**

Until about 1965, nearly all the northern corn rootworm (NCR) reproduced a single generation yearly. Because it could only survive on cultivated corn and its dispersal stage never coincided with the beginning of a cropping season, crop rotation controlled this pest in Iowa corn fields for over a century.

## **Keywords**

Entomology, Biocontrol, Integrated pest management

## **Disciplines**

Agriculture | Entomology



## Evaluation for an integrated pest management program for northern corn rootworm extended diapause

### Goals

Until about 1965, nearly all the northern corn rootworm (NCR) reproduced a single generation yearly. Because it could only survive on cultivated corn and its dispersal stage never coincided with the beginning of a cropping season, crop rotation controlled this pest in Iowa corn fields for over a century.

But the NCR has gradually adapted, and an increasing proportion of the NCR beetles' eggs have failed to hatch the first spring, overwintering to a second year. This delay occurs during diapause, the eggs' resting stage; thus, the trait is termed extended diapause. *One 1986 study reported that up to 47 percent of the NCR counted in three neighboring states possessed the two-year lifecycle!*

*Currently, farmers whose fields first suffer an infestation of extended-diapause NCR witness dramatic consequences: mature corn lying flat on the ground (see photo, p. 56). This highly visible damage has accelerated awareness and concern, but government subsidy programs discourage farmers from growing corn in longer-term rotations that would defy the NCR.*

The only currently effective alternative is application of soil insecticides at planting. *If chemicals are employed in rotated corn production as enthusiastically as they have been on continuous corn, up to 78 percent of the rotated corn grown in Iowa would be arbitrarily treated with insecticides to guard against rootworms.*

Because of the potential negative impact of these chemicals on the environment, this project

sought to assess the risk the extended-diapause NCR variety poses to rotated corn and develop practical economic-decision thresholds (the point at which a control practice becomes economically feasible) that can help to prevent unnecessary insecticide use.

### Approach

**1988:** Because the 35 northwestern counties of Iowa were determined to be at risk from extended-diapause NCR infestation, project researchers conducted a random survey and sampling of the area involving 317 farmers.

Three teams of scientists rotated among counties; each team sampled in each county. Fields were selected at random, not because the farmer perceived a NCR problem. Beetles were counted on 20 plants per field; researchers then classified the fields as having (1) no beetles (per plant); (2) 0-1 beetle; (3) 1-2 beetles; (4) 2-4 beetles; or (5) more than 4 beetles. To help verify that the beetles had originated in that field, scientists examined plant roots for larval feeding, a reliable indicator of origination. Samplers also recorded corn variety, planting date, and insecticide use. (Except for a few treatments applied for other pests, 47 of the farmers used insecticide as a precaution after noticing NCR damage the previous year.)

Researchers also placed insect cages in the fields of four farmers reporting larval damage in 1986. In addition to documenting the distribution of beetles within fields, caging of the live beetles provided specimens to test the usefulness of an analysis technique for assessing gene mixing and other inheritance aspects of NCR extended diapause.

### Principal Investigator

Jon J. Tollefson  
Entomology  
Iowa State University

### Budget

\$79,704 for year one  
\$25,518 for year two  
\$26,393 for year three

To estimate the economic impact of the NCR in rotated corn, researchers sampled machine-harvested grain from insecticide-treated as well as untreated strips in these four farmers' fields as well as five additional cooperators' fields that had suffered rootworm damage in rotated corn. The latter contained NCR present in numbers probably sufficient to include some of the extended-diapause variety. Egg samples were collected to relate number of NCR eggs to subsequent larval damage in fields where corn and soybeans were rotated.

**1989:** Researchers sampled contiguous counties using a regular sampling pattern that relied on a widely accepted sampling design. The sampling included 116 sites in 19 counties. Because of the good correlation between root damage ratings and beetle counts within fields in 1988, as well as to expedite sampling of all fields before beetles could disperse, beetle counts alone were taken on 20 plants per field. The genetic studies also continued.

**1990 and 1991:** *Because of the extended-diapause NCR's two-year lifecycle, larval damage resulting from an adult infestation does not occur until the second growing season after beetles are present.* Thus, to develop a damage-prediction threshold, researchers had to assess larval damage in 1990 and 1991 in the

same fields where beetle densities were classified in 1988 and 1989, respectively. During 1990, larval feeding suffered by 20 plants was analyzed in 152 fields where beetle density had been assessed in 1988. Researchers classified larval feeding by using a standard rating scale. In 1991, they used the scale to analyze larval feeding on 10 corn plants in each of the 116 fields. Beetle densities had also been determined in 79 of the fields during 1988.

## Findings

**1988:** Northern corn rootworms were found in 94 percent of the 1988 fields. Heavier infestations in the northern and central tiers of counties support a state-wide trend toward higher populations in northern Iowa (see Table 1).

A threshold in continuous corn (1 beetle/plant) established in an earlier study was applied to fields with beetles; by this criterion, 42 percent of the fields had non-economic infestations. Of the economic infestations, 30 percent had heavy beetle populations. Few fields, however, suffered larval damage that warranted insecticides during 1988; 235 fields suffered no economic damage, and 36 were at the economic threshold, which ranges from slight root pruning to one destroyed root node.

**Table 1. Frequency of fields possessing extended-diapausing northern corn rootworm populations in nine counties representative of the northwestern third of Iowa.**

		Number of beetles per plant			
County	0	0-1	1-2	2-4	>4
<i>Northern tier</i>					
-O'Brien	1	0	7	11	13
-Dickinson	0	12	9	6	3
-Kossuth	3	13	7	9	7
<i>Central tier</i>					
-Ida	0	4	1	6	12
-Pocahontas	3	10	12	6	1
-Humboldt	2	16	7	9	6
<i>Southern tier</i>					
-Shelby	2	20	4	2	2
-Audubon	2	21	3	1	0
-Dallas	2	13	3	1	0
TOTALS	15	109	53	51	44

Abundant beetles in the nine fields that contained both insecticide-treated and -untreated strips offered additional proof that rootworms can survive in Iowa corn grown in a two-year corn-soybean rotation. (Because nearly all the adult rootworm beetles collected were the northern variety, researchers surmise that the extended diapause trait is currently confined to that species.)

Although insecticides improved yields in those fields where treated and untreated strips were sampled, differences were small and positive only 55 percent of the time. At 1988 crop prices and insecticide costs, only one of the nine fields would have provided a return for using the insecticide.

Currently, the accepted rootworm-control threshold based on egg sampling is five eggs per pint of soil, a level exceeded by none of the 1988 fields sampled that were to be planted to corn in 1989. Thus, severe NCR larval damage was not expected in 1989.

The genetic analysis technique proved useful for studying the inheritance of the extended-diapause trait and measuring the degree of gene mixing between the regular NCR and the extended-diapause NCR.

**1989:** The 1989 survey design, which built on these 1988 results, included only 19 counties (with Webster as the southeasternmost) to allow a more intensive survey, and it arranged the fields to assure adequate, uniformly distributed sampling. Scientists actually counted beetles per plant rather than assigning fields a density category as described earlier.

Although one field averaged 11.5 beetles/plant, almost 45 percent of the fields had fewer than one beetle/plant. Nearly 90 percent did not exceed four beetles/plant.

**1990:** Researchers determined economic injury levels in part by quantifying the relationship of root damage by larvae to parent beetle densities. The method allowed them to chart trends in economic root damage, beetle densities in relation to larval damage, and the effect

of beetle density on root damage in subsequent corn plantings.

**1991:** In estimates of the relationship between root damage and previous beetle densities from the 79 corn fields sampled in 1991, about one-third of the damage was explained by the 1989 adult densities. Results were similar to those of the previous two years.

Overall, data indicate that beetle populations must exceed four per plant before economic larval damage is likely to result. This threshold was surpassed in only 49 of 231 fields surveyed over three years. By substituting (1) the frequency with which economic damage is predicted, and (2) the frequency with which the damage was actually realized, into calculations developed by another study, researchers can estimate the value of sampling for extended-diapause NCR.

## Implications

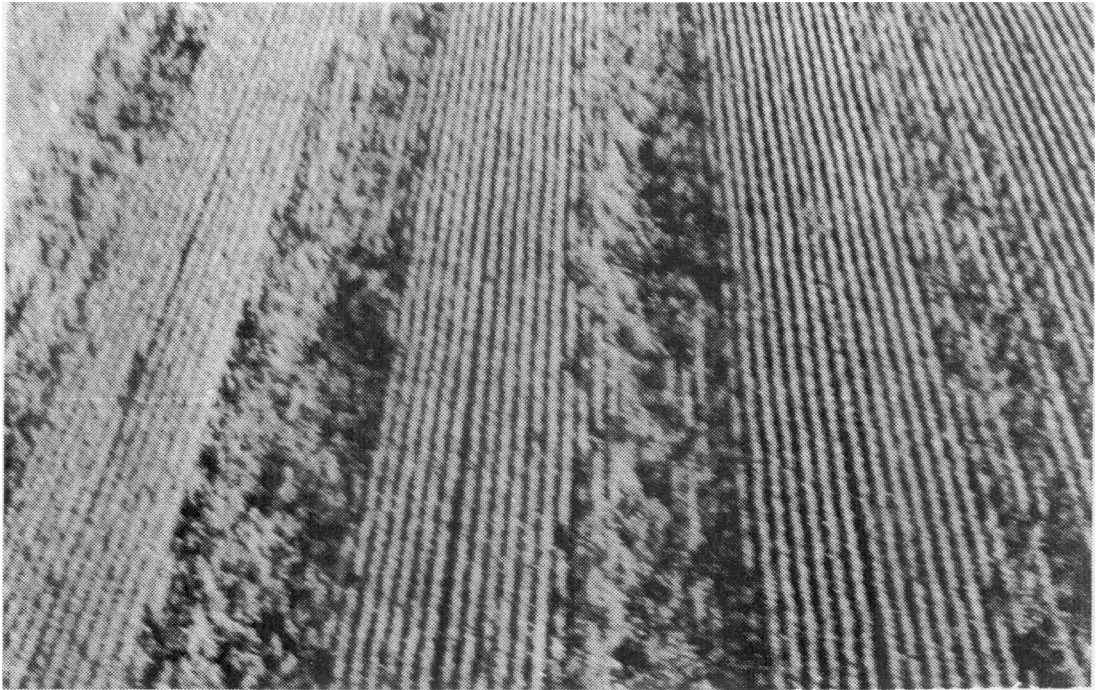
This survey of NCR adult populations and larval damage, and the analysis of beetles caught in cages, clearly demonstrate that corn rotated with soybeans can suffer corn rootworm larval damage caused by a NCR variety that has developed a two-year lifecycle.

An earlier study found that the average population densities of corn rootworms *in continuous corn* were so close to the economic threshold of one beetle/plant that sampling to predict the need for insecticide treatments did not reduce management costs. *But this study demonstrated that more than one extended-diapause NCR beetle/plant must be present before economic damage occurs.* And NCR beetle densities must exceed four beetles/plant *in rotated corn* before the likelihood of economic larval damage becomes as high as one in three.

Scouting rotated corn fields for NCR to predict the need for insecticides is a practice that can save an estimated \$4.06/acre. *And this figure does not reflect the environmental benefits of withholding unnecessary insecticides.*

In Iowa, the greatest likelihood of NCR larval damage in rotated corn exists in the northwestern counties. Rotation of corn with soybeans is also most prevalent here. But it is important for farmers to know that *an economically damaging infestation level in a field located close by does not increase their individual likelihood of infestation*. Scouting for beetles to predict the need for insecticides, at least in rotated corn fields, is clearly a valuable practice.

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This aerial shot of a corn field shows strips of standing rows (where insecticide was used) intermixed with strips of corn decimated by the northern corn rootworm. Scouting can help reduce insecticide use without putting crops at risk for such damage.